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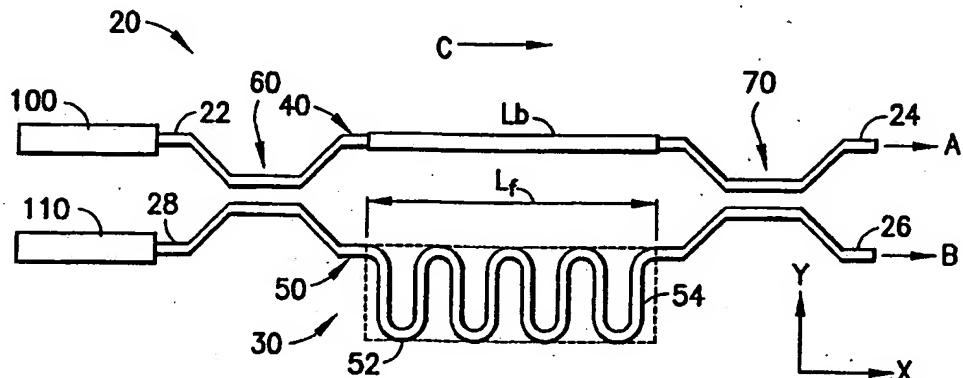
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(54) Title: A NANOPHOTONIC MACH-ZEHNDER INTERFEROMETER SWITCH AND FILTER



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(57) Abstract: A nanophotonic Mach-Zehnder interferometer (MZI) (20) device having at least one arm (50) which has an actual length greater than its virtual length ( $L_v$ ). An arcuate section (52) is provided in at least one arm (50) (thus providing a "meandering arm") to increase the actual length of that arm without increasing its virtual length ( $L_v$ ) and without compromising the ability of that arm to effect a  $\pi$  phase shift in an optical signal propagating therein. By constructing the MZI device of strongly confined waveguides, which may be either photonic-well or photonic-wire devices, the low bending loss characteristics of such waveguides enable the use of an arcuate section (52) or bend in the waveguide without experiencing undesirable losses in the optical signal. The actual length of the arm and the optical length are equivalent to those for prior art devices and sufficient to introduce the desired phase shift. In contrast to prior art devices, however, the present invention provides those sufficient actual and optical lengths in a significantly reduced length on the chip (i.e., its virtual length) that requires less on-chip real estate and thus provides for denser integration of a plurality of optical devices in an optical component.

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 G02F1/225 G02B6/12

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## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 289 256 A (GRAMLING HUBERT) 22 February 1994 (1994-02-22)	1-5, 7, 10-14, 18-22, 26-30 8, 9, 16, 17, 24, 25, 32, 33
Y	column 3, line 59 -column 4, line 19  column 5, line 42 - line 64 column 7, line 22 -column 60 column 9, line 3 - line 53; figures 3-5  -/-	

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 930 412 A (TOUSSAERE ERIC) 27 July 1999 (1999-07-27)	1,2,5,7, 10,11, 14,18, 19,22, 26,27,30
Y	column 6, line 39 -column 7, line 6; figure 21	8,9,16, 17,24, 25,32,33
X	KHALFALLAH S ET AL: "Highly unbalanced GaAlAs-GaAs integrated Mach-Zehnder interferometer for coherence modulation at 1.3 $\mu$ m" OPTICS COMMUNICATIONS, NL, NORTH-HOLLAND PUBLISHING CO. AMSTERDAM, vol. 167, no. 1-6, 15 August 1999 (1999-08-15), pages 67-76, XP004176850 ISSN: 0030-4018 Chapters 2, 3 figures 1-6	1,2,5, 26,27,30
Y	US 5 790 583 A (HO SENG-TIONG) 4 August 1998 (1998-08-04) the whole document	8,9,32, 33
Y	US 5 878 070 A (HO SENG-TIONG ET AL) 2 March 1999 (1999-03-02) the whole document	6,15,23, 31
		8,16,24, 32
		9,17,25, 33

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

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Patent document cited in search report		Publication date		Patent family member(s)		Publication date
US 5289256	A	22-02-1994		DE 4204521 C FR 2687472 A GB 2264183 A, B IT 1262345 B JP 2081113 C JP 6094425 A JP 7097017 B		24-06-1993 20-08-1993 18-08-1993 19-06-1996 09-08-1996 05-04-1994 18-10-1995
US 5930412	A	27-07-1999		FR 2749945 A EP 0816896 A		19-12-1997 07-01-1998
US 5790583	A	04-08-1998		US 5825799 A AU 3368897 A WO 9744870 A US 6009115 A US 5926496 A CA 2220249 A CN 1185238 A EP 0829119 A JP 11507471 T WO 9637932 A US 5878070 A		20-10-1998 09-12-1997 27-11-1997 28-12-1999 20-07-1999 28-11-1996 17-06-1998 18-03-1998 29-06-1999 28-11-1996 02-03-1999
US 5878070	A	02-03-1999		US 5825799 A AU 3210897 A WO 9744871 A CA 2220249 A CN 1185238 A EP 0829119 A JP 11507471 T WO 9637932 A US 6009115 A US 5790583 A US 5926496 A		20-10-1998 09-12-1997 27-11-1997 28-11-1996 17-06-1998 18-03-1998 29-06-1999 28-11-1996 28-12-1999 04-08-1998 20-07-1999